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MEMORANDUM REPORT NO. 2002

STANDARD CONDITIONS FOR CANNON ARTILLERY FIRING TABLES

by

Donald H. McCoy

August 1969

U.S. ARMY ABERDEEN RESEARCH AND DEVELOPMENT CENTER
BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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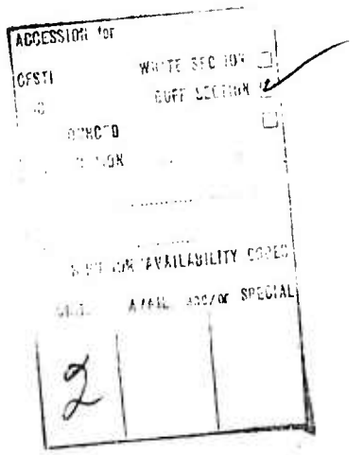

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BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 2002

AUGUST 1969

STANDARD CONDITIONS FOR CANNON ARTILLERY FIRING TABLES

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RDT&E Project No. 1T562603A287

ABERDEEN PROVING GROUND, MARYLAND

BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 2002

DHMcCoy/bkd
Aberdeen Proving Ground, Md.
August 1969

STANDARD CONDITIONS FOR CANNON ARTILLERY FIRING TABLES

ABSTRACT

An investigation was conducted to determine the advisability of changing the standards of density and muzzle velocity used in the computation of firing tables. It was found that the introduction of "more realistic" values for these parameters does not improve the accuracy of the tables sufficiently to warrant their use at the present time.

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I. INTRODUCTION

For many years, the United States has generated cannon artillery firing tables with a standard density based on sea level (zero altitude) and a standard muzzle velocity equivalent to that which is obtained from a new tube. These standards have often been questioned, and with good reason. The mean battlefield height is, of course, not sea level; and the mean velocity obtained in a field situation is almost always less than that for a new tube. Therefore, this study was conducted to determine if an improvement in target hits would result from the use of a firing table based on "more realistic" standard conditions.

II. BASIC CONSIDERATIONS

A. Weapon/Charge Combinations

The weapon/charge combinations considered were:

Weapon	Charges
105mm How., M108	3, 6, 7
155mm How., M109	3, 5, 7, 8
175mm Gun, M107	1, 2, 3

B. Firing Tables

For purposes of the investigation, firing tables consisting of standard range/elevation relationships and range corrections were computed based on both the current and proposed standards listed on the following page.

As a proposed standard for density, a figure of 95% of the 1962 ICAO standard value was chosen. This represents the mean ballistic density of world-wide Honest John Rocket troop firings and implies a

Current Standards

Parameter		Standard	Perturbations
Density (% ICAO)		100	± 10
Temperature (% ICAO)		100	± 10
Range Wind (knots)		0	± 50
Velocity (m/sec)			± 15
Weapon	**Charge**		
105mm	3	247	
	6	393	
	7	494	
155mm	3	273	
	5	378	
	7	561	
	8	684.3	
175mm	1	510.5	
	2	704.1	
	3	914.4	

Proposed Standards

Parameter		Standard	Perturbations
Density (% ICAO)		95	± 7
Temperature (% ICAO)		100	± 5
Range Wind (knots)		0	± 20
Velocity (m/sec)			± 7
Weapon	**Charge**		
105mm	3	243	
	6	389	
	7	490	
155mm	3	264	
	5	369	
	7	552	
	8	675	
175mm	1	503	
	2	697	
	3	907	

mean battlefield height of approximately 500 meters. Estimates obtained from wear data for each weapon served as proposed standard velocities.

Since the magnitude of current perturbations is thought to be extreme in most cases, it should be noted that those used with the proposed standards have been decreased for this study.

C. Parameters

Fifty random samples of density, temperature, velocity and range wind were used and are the same as those given in Tables I, II and III of BRL Memorandum Report No. 1978.

III. PROCEDURES

The firing tables computed with current and proposed standards of density and velocity were utilized to solve fire problems based on the 50 sets of random nonstandard conditions set up for each weapon system. Problems were solved at five ranges per weapon/charge combination with the resultant quadrant elevations serving as inputs to trajectories that were then run under identical conditions of weather and materiel. The difference between the target and trajectory range was accepted as a measure of firing table accuracy. Subsequently, these differences were analyzed at each range in the following manner:

1. The mean and standard deviation were computed for the 50 range differences and are listed in Table I. Note that in some instances less than 50 fire problems could be solved.

2. A probable error of .3% of range was assumed at each target. This probable error was then converted to a standard deviation.

3. The standard deviations found in 1 and 2 were combined.

4. Using the combined distribution, the percent of rounds falling between plus and minus one probable error was determined.

This percent was also determined for plus and minus two probable errors. These values appear in Table II.

5. Steps 2 through 4 were repeated for a probable error equal to .6% of range, and the results tabulated in Table III.

IV. SUMMARY OF RESULTS

Weapon	The Percent of Rounds Falling Within Plus and Minus One Probable Error		Two Probable Errors	
	Current Standards	Proposed Standards	Current Standards	Proposed Standards
for a Probable Error Equal to .3% of Range				
105	46.59	48.92	78.65	81.15
155	47.48	48.99	79.60	81.22
175	47.76	48.55	79.83	80.75
	47.28	48.84	79.37	81.06
for a Probable Error Equal to .6% of Range				
105	49.09	49.72	81.33	81.98
155	49.33	49.74	81.58	82.00
175	49.37	49.62	81.61	81.88
	49.26	49.70	81.51	81.96

NOTE: If there were no aiming errors inherent in the firing table, 50% of the rounds would fall between plus and minus 1 probable error and 82.3% would fall between plus and minus 2 probable errors.

V. CONCLUSIONS

As shown by this study, neither the proposed standards of density and velocity nor the modified perturbations used in the computation of firing tables offer a significant improvement over those currently used. Although at nearly all the weapon/charge/range combinations tested, an increase is noted in the percent of rounds falling within the limits of one or two probable errors, there are only a few rounds for which this increase is meaningful. In view of the fact that firing tables are constructed to meet world-wide application, the current standard of 100% ICAO for density is acceptable. However, if tables are ever computed for particular areas of the globe, a more realistic value should be chosen for those areas having very high or very low altitudes.

Table I. Mean Range Errors and Standard Deviations

WPN	CHG	RANGE METERS	MEAN RANGE ERROR IN METERS		STANDARD DEVIATION IN METERS		NUMBER OF CASES	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS	CURR STDS	PROP STDS
105mm	3	1300	2.574	1.176	1.310	.534	50	50
		2600	5.568	.954	2.548	1.093	50	50
		3900	8.702	1.486	4.483	2.247	50	50
		4000	9.070	1.976	4.720	2.427	50	50
		3900	7.420	2.040	4.480	2.466	50	50
	6	2400	- 2.118	- 1.050	2.390	2.211	50	50
		4800	.114	- .450	5.501	4.671	50	50
		7200	5.544	.810	9.992	7.931	50	50
		8000	6.832	1.152	11.716	9.492	50	50
		6800	6.758	1.272	10.312	7.380	50	50
	7	2900	1.318	- .238	1.899	1.470	50	50
		5800	- 1.296	.050	7.367	6.685	50	50
		8600	4.070	.610	13.678	10.840	50	50
		10400	9.462	.646	20.702	15.564	50	50
		8200	4.490	.810	10.624	9.042	49	50

Table I. Mean Range Errors and Standard Deviations (Continued)

WPN	CHG	RANGE METERS	MEAN RANGE ERROR IN METERS		STANDARD DEVIATION IN METERS		NUMBER OF CASES	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS	CURR STDS	PROP STDS
155mm	3	1600	1.804	- .030	1.636	.553	50	50
		3200	4.914	.546	2.933	1.517	50	50
		4800	7.076	1.000	5.178	3.026	50	50
		5800	13.232	2.680	5.761	3.813	47	41
		4500	6.608	1.312	4.973	2.804	50	50
	5	2500	- 4.124	- .694	5.796	3.715	50	50
		5000	- .478	.268	6.489	4.570	50	50
		7500	4.822	.782	7.456	6.917	50	50
		9000	7.786	1.118	10.271	9.457	50	50
		7000	5.028	2.164	9.780	6.603	50	50
	7	3600	1.476	- .132	2.752	2.316	50	50
		7300	- 1.664	- .586	7.504	7.095	50	50
		11000	2.578	.180	15.009	12.796	50	50
		13200	9.272	.624	22.826	19.787	50	50
		10200	3.158	.764	11.870	9.544	50	50
	8	4500	3.872	- 1.274	4.016	3.100	50	50
		9000	2.148	- .478	9.237	7.604	50	50
		13500	.466	- 1.448	19.930	16.535	50	50
		16900	9.934	3.794	26.529	25.058	31	49
		15400	1.220	.632	14.084	11.602	50	50

Table I. Mean Range Errors and Standard Deviations (Continued)

WPN	CHG	RANGE METERS	MEAN RANGE ERROR IN METERS		STANDARD DEVIATION IN METERS		NUMBER OF CASES	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS	CURR STDS	PROP STDS
175mm	1	3800	.974	.572	3.302	2.671	50	50
		7600	- 3.050	- 1.662	6.484	6.070	50	50
		11300	- 2.054	- 1.126	13.591	11.758	50	50
		14300	1.632	.214	17.808	15.761	31	49
		12600	3.355	.896	11.582	8.277	49	49
	2	5500	2.028	.820	4.120	3.736	50	50
		11100	4.470	- .538	13.155	12.395	50	50
		16600	- 4.874	- 2.436	23.766	19.442	50	50
		20900	- 3.326	- .502	34.375	32.607	31	49
		19100	.795	3.151	19.597	16.323	38	45
	3	8200	.940	- 2.040	5.328	6.457	50	50
		16400	4.718	- 1.052	20.907	22.051	50	50
		24500	9.132	- 1.046	50.196	43.169	50	50
		30200	56.153	7.000	96.151	63.261	49	49
		30000	20.483	12.261	41.463	28.310	36	36

Table II. The Percent of Rounds Falling Within Plus and Minus One and Two Probable Errors of Target Range
(Probable Error Equals .3% of Range)

WPN	CHG	RANGE METERS	ONE PROBABLE ERROR		TWO PROBABLE ERRORS	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS
105mm	3	1300	45.11	48.95	77.09	81.19
		2600	44.53	49.67	76.46	81.93
		3900	43.90	49.49	75.74	81.75
		4000	43.71	49.35	75.52	81.60
		3900	45.15	49.28	77.11	81.54
	6	2400	48.17	48.91	80.37	81.14
		4800	48.63	49.00	80.86	81.23
		7200	47.47	48.72	79.61	80.95
		8000	47.14	48.52	79.25	80.73
		6800	46.76	48.74	78.83	80.96
	7	2900	49.32	49.72	81.58	81.98
		5800	48.29	48.62	80.49	80.84
		8600	47.26	48.36	79.37	80.56
		10400	45.48	47.73	77.38	79.89
		8200	47.98	48.72	80.16	80.95

Table II. The Percent of Rounds Falling Within Plus and Minus One and Two Probable Errors of Target Range
(Probable Error Equals .3% of Range) Continued

WPN	CHG	RANGE METERS	ONE PROBABLE ERROR CURRENT STANDARDS	ONE PROBABLE ERROR PROPOSED STANDARDS	TWO PROBABLE ERRORS CURRENT STANDARDS	TWO PROBABLE ERRORS PROPOSED STANDARDS
155mm	3	1600	47.63	49.87	79.80	82.14
		3200	46.75	49.73	78.87	81.99
		4800	46.64	49.53	78.74	81.79
		5800	43.94	49.31	75.81	81.57
		4500	46.61	49.50	78.70	81.75
	5	2500	42.92	47.69	74.35	79.85
		5000	48.26	49.12	80.46	81.36
		7500	48.54	49.09	80.76	81.33
		9000	47.90	48.83	80.08	81.06
		7000	47.52	48.97	79.66	81.20
	7	3600	49.20	49.56	81.45	81.81
		7300	48.84	49.00	81.07	81.24
		11000	48.04	48.59	80.23	80.81
		13200	46.60	47.73	78.64	79.89
		10200	48.50	49.07	80.71	81.31
	8	4500	48.40	49.41	80.62	81.66
		9000	48.84	49.24	81.07	81.49
		13500	47.79	48.44	79.96	80.65
		16900	47.20	47.73	79.32	79.89
		15400	49.11	49.39	81.35	81.65

Table II. The Percent of Rounds Falling Within Plus and Minus One and Two Probable Errors of Target Range
(Probable Error Equals .3% of Range) Continued

WPN	CHG	RANGE METERS	ONE PROBABLE ERROR		TWO PROBABLE ERRORS	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS
175mm	1	3800	49.13	49.45	81.38	81.70
		7600	49.06	49.27	81.31	81.52
		11300	48.47	48.86	80.68	81.09
		14300	48.39	48.73	80.59	80.96
		12600	49.04	49.53	81.28	81.79
	2	5500	49.26	49.48	81.51	81.74
		11100	48.38	48.70	80.59	80.92
		16600	47.83	48.56	80.00	80.77
		20900	47.28	47.55	79.40	79.70
		19100	48.90	49.20	81.13	81.45
	3	8200	49.54	49.28	81.79	81.53
		16400	48.25	48.14	80.44	80.34
		24500	45.87	46.94	77.82	79.02
		30200	39.54	45.78	70.01	77.72
		30000	47.60	48.89	79.75	81.13

Table III. The Percent of Rounds Falling Within Plus and Minus One and Two Probable Errors of Target Range
(Probable Error Equals .6% of Range)

WPN	CHG	RANGE METERS	ONE PROBABLE ERROR		TWO PROBABLE ERRORS	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS
105mm	3	1300	48.69	49.73	80.93	82.00
		2600	48.53	49.92	80.76	82.18
		3900	48.34	49.87	80.57	82.14
		4000	48.28	49.84	80.50	82.10
		3900	48.70	49.82	80.93	82.08
	6	2400	49.53	49.72	81.78	81.98
		4800	49.65	49.74	81.91	82.01
		7200	49.33	49.67	81.58	81.93
		8000	49.24	49.62	81.49	81.88
		6800	49.13	49.68	81.38	81.94
	7	2900	49.83	49.93	82.09	82.19
		5800	49.56	49.64	81.81	81.90
		8600	49.27	49.57	81.52	81.83
		10400	48.75	49.40	80.98	81.66
		8200	49.47	49.67	81.73	81.93

Table III. The Percent of Rounds Falling Within Plus and Minus One and Two Probable Errors of Target Range (Probable Error Equals .6% of Range) Continued

WPN	CHG	RANGE METERS	ONE PROBABLE ERROR CURRENT STANDARDS	ONE PROBABLE ERROR PROPOSED STANDARDS	TWO PROBABLE ERRORS CURRENT STANDARDS	TWO PROBABLE ERRORS PROPOSED STANDARDS
155mm	3	1600	49.38	49.97	81.64	82.23
		3200	49.15	49.93	81.40	82.20
		4800	49.11	49.88	81.36	82.15
		5800	48.37	49.83	80.59	82.09
		4500	49.10	49.87	81.35	82.14
	5	2500	47.93	49.39	80.11	81.65
		5000	49.55	49.77	81.81	82.04
		7500	49.62	49.77	81.88	82.03
		9000	49.45	49.70	81.71	81.96
		7000	49.34	49.74	81.60	82.00
	7	3600	49.80	49.89	82.06	82.15
		7300	49.70	49.74	81.96	82.01
		11000	49.49	49.64	81.75	81.90
		13200	49.08	49.40	81.32	81.66
		10200	49.61	49.76	81.87	82.03
	8	4500	49.59	49.85	81.85	82.11
		9000	49.70	49.81	81.96	82.07
		13500	49.42	49.60	81.67	81.85
		16900	49.26	49.40	81.50	81.66
		15400	49.77	49.85	82.04	82.11

Table III. The Percent of Rounds Falling Within Plus and Minus One and Two Probable Errors of Target Range
(Probable Error Equals .6% of Range) Continued

WPN	CHG	RANGE METERS	ONE PROBABLE ERROR		TWO PROBABLE ERRORS	
			CURRENT STANDARDS	PROPOSED STANDARDS	CURRENT STANDARDS	PROPOSED STANDARDS
175mm	1	3800	49.78	49.86	82.04	82.12
		7600	49.76	49.82	82.02	82.08
		11300	49.60	49.71	81.86	81.97
		14300	49.58	49.67	81.84	81.94
		12600	49.75	49.88	82.02	82.15
	2	5500	49.81	49.87	82.08	82.13
		11100	49.58	49.67	81.84	81.93
		16600	49.43	49.63	81.69	81.89
		20900	49.28	49.35	81.53	81.61
		19100	49.72	49.80	81.98	82.06
	3	8200	49.88	49.82	82.15	82.08
		16400	49.54	49.52	81.80	81.77
		24500	48.87	49.18	81.10	81.43
		30200	46.67	48.84	78.72	81.07
		30000	49.37	49.72	81.62	81.98

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13. ABSTRACT

An investigation was conducted to determine the advisability of changing the standards of density and muzzle velocity used in the computation of firing tables. It was found that the introduction of "more realistic" values for these parameters does not improve the accuracy of the tables sufficiently to warrant their use at the present time.

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